Space-Efficient Visualisation of Large Hierarchies

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Abstract

Relational information visualisation concerns viewing relational data, where the underlying data model is a graph. Hierarchical visualisation is one of hot topics in graph visualisation in which the data is organised in a hierarchical structure. As the amount of information, that we want to visualise, becomes larger and the relations become more complex, classical visualisation techniques and hierarchical drawing methods tend to be inadequate.

Traditional hierarchical visualisation algorithms are more concerned with the readability of the layouts. They usually do not consider the efficient utilisation of the geometrical plane for the drawings. Therefore, for most hierarchical layouts, a large portion of display space is wasted as background. The aim of this research is to investigate a space-efficient approach to handle the visualisation of large hierarchies in two-dimensional spaces.

This thesis introduces a new graph visualisation approach called *enclosure+ connection* for visualizing large hierarchies. This approach maximises the space utilisation by taking advantages of the traditional enclosure partitioning approach, while it retains the display of a traditional node-link diagram to hopefully provide users a direct perception of relational structures.

The main contribution of this thesis is layout and navigation algorithms for visualising large hierarchies. Two layout algorithms, the *space-optimised tree* and the *EncCon tree*, have been developed to achieve the space-efficient visualisation. Both algorithms use the enclosure concept to define layout of hierarchies, which ensure the efficient utilisation of display space. Two *focus+context* navigation and interaction methods have been proposed to cooperate with the visualization of large hierarchies. Several advanced computer graphics approaches, such as *graphic distortion* and *transparency*, are used for the development of these navigation methods.

Two case studies have been implemented to evaluate the layout algorithms and the associated navigation methods. The first case study is an application of a shared collaborative workspace which aims to provide users with a better assistance for visual manipulation and navigation of knowledge-based information. The second case study is a visual browser for navigating large-scale online product catalogues.

Although the case studies have provided some useful evaluation, formal usability studies would be required to justify fully the effectiveness of these layout and navigation methods. Although this task has not carried out in this research, the author has presented his usability study's plan as a future work.

Terminology

- **A graph $G = \{V, E\}$:** is defined as a pair (V, E), where V is a set of vertices, and E is a set of edges between the vertices $E = \{(u,v) \mid u, v \in V\}$.
- **A tree**: is a connected graph without a cycle.
- **A rooted tree:** consists of a tree $T(r)$ and a distinguished vertex r. The vertex r is called the root of T. In other words, T can be viewed as a directed acyclic graph with all edges oriented away from the root. If (μ, ν) is a directed edge in T, we then say μ is the father of ν, or ν is a child of μ. If T contains vertex ν, then the sub-tree $T(\nu)$ rooted at ν is the sub-graph induced by all vertices on paths originating from ν.
- **A leaf vertex:** is a vertex with no children.
- **A node:** represents a vertex with its displaying properties.
- **Weight $w(\nu)$:** represents the weight of vertex ν.
- **Wedge $wg(\nu)$:** is defined by a vertex μ, line l goes through μ, and a clockwise angle $\alpha(\nu)$; where μ is the father of ν. Thus, we have $wg(\nu) = \{\mu, l, \alpha(\nu)\}$ (see Figure 2.3).
- **Local region $R(\nu)$:** is an area which contains the drawing of a sub-tree $T(\nu)$.
  - At the Space-Optimised Tree model: $R(\nu)$ is a polygon that is defined by the wedge $wg(\nu)$ and one (or more) cutting edges (boundaries of other local regions) that cross the line l in $wg(\nu)$ (see Figure 2.4).
  - At the EncCon model: $R(\nu)$ *is* a rectangle.
- **Layered visualisation LV:** consists of two graphical layers L_1 and L_2 of the information that are appeared in an overlapped manner in the visualisation, $LV = L_1 + L_2$ (see Figure 3.8). Each layer is the medium for the drawing of graph G or a sub-graph $G_l \in G$. At any time, a graph G_i drawn in L_1 is always a sub-graph of G_j drawn in L_2. Thus, we constantly have $G_i \in G_j \in G$.